DYNAMIC LOADING METHODOLOGIES
(Flutter Response of a Damaged Fighter Aircraft Wing)

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Acknowlegements

- Computer Resources Provided by ASC/MSRC
- This Work is Funded by the Joint Technical Coordinating Group for Aircraft Survivability (JTCG/AS), Vulnerability Reduction Subgroup
- Technical oversight by 46th Test Wing, Aerospace Vehicle Survivability Flight, Wright-Patterson AFB, OH

Overview

- Background
- Model Validation Plan
- Model Validation Results
- Sample Cases
- Conclusions

Resources Used

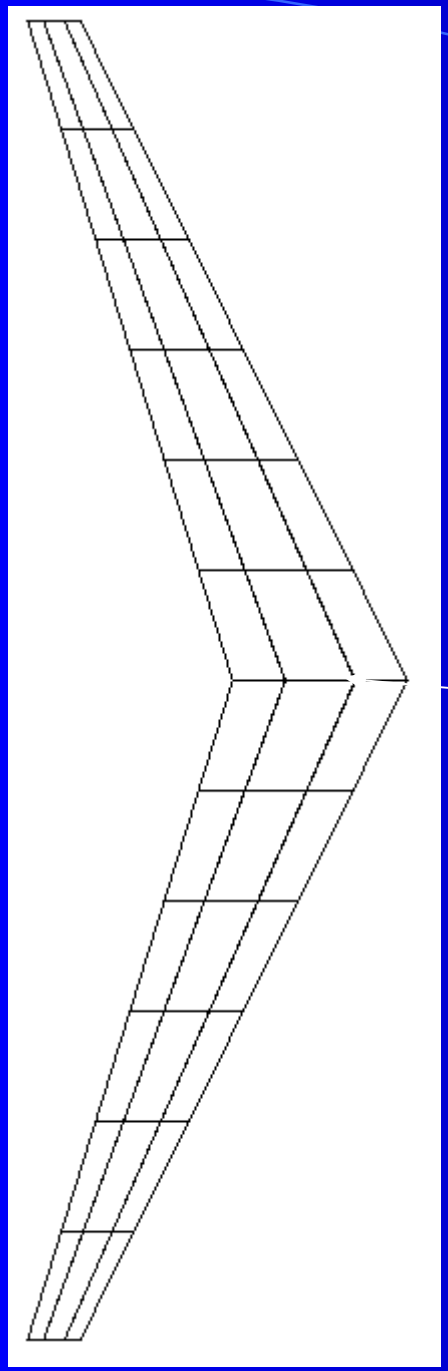
- **Software:**
  - Pre-Processing: MSC/PATRAN, LS-INGRID,FEMB
  - Analysis: LSDYNA3D Version 960 (Livermore Software Technology Corp.)
  - Post-Processing: LS-POST,ENSIGHT7
- **Hardware: ASC/MSRC (1 to 8 Processors)**
  - SGI Origin 2000
  - COMPAQ GS-320, ES-40, ES-45
  - SGI Linux (RedHat 7.)
- **68 Different Cases**
  - 25000 Degrees of Freedom
  - Approximately 19 Hours of CPU Time/Case
  - 1300 Total CPU Hours

Background

- Dynamic => Need to Know Stiffness and Mass Distributions

- Mass Distribution => Need to Know Store & Fuel Loading on Wings

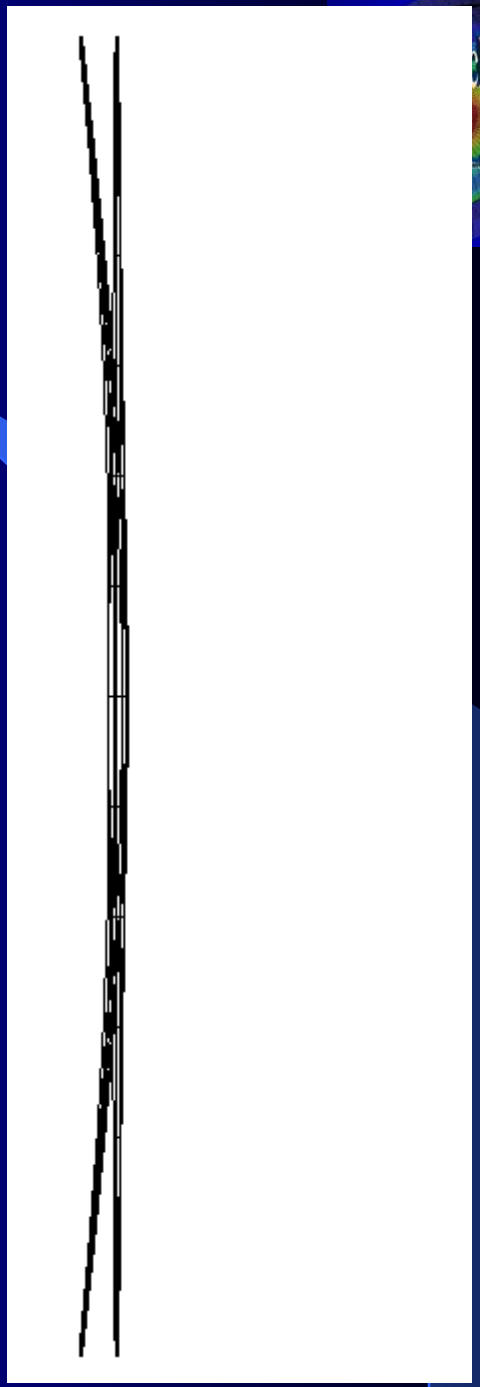
- Stiffness and Mass Distributions Change Instantaneously When Damage is Inflicted



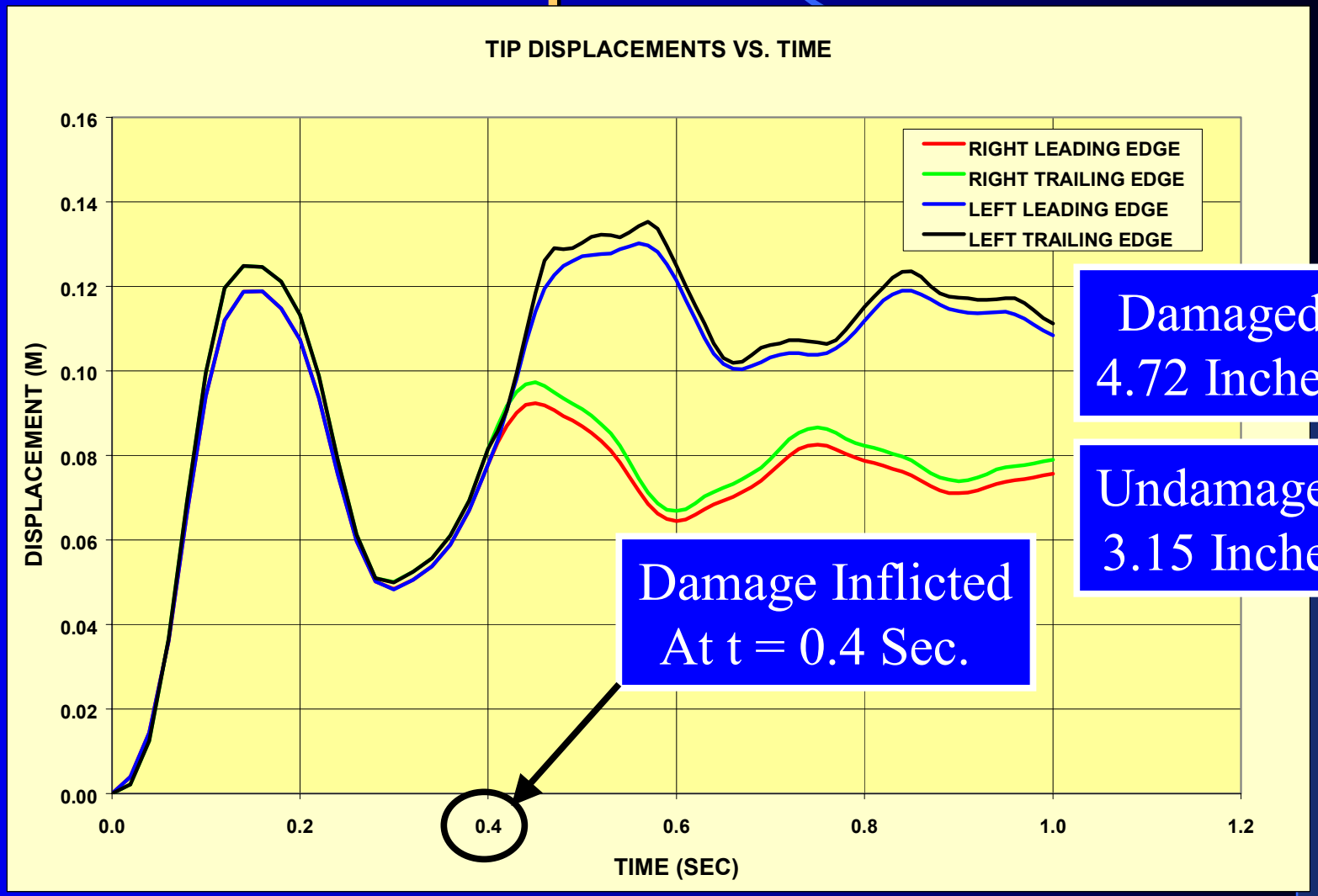
- 2-Spar Wing
- NACA 0012 1.0m-root
- NACA 0006 0.3m-tip
- 7.5m Span
- Flutter Speed 250m/sec

Sample Problem

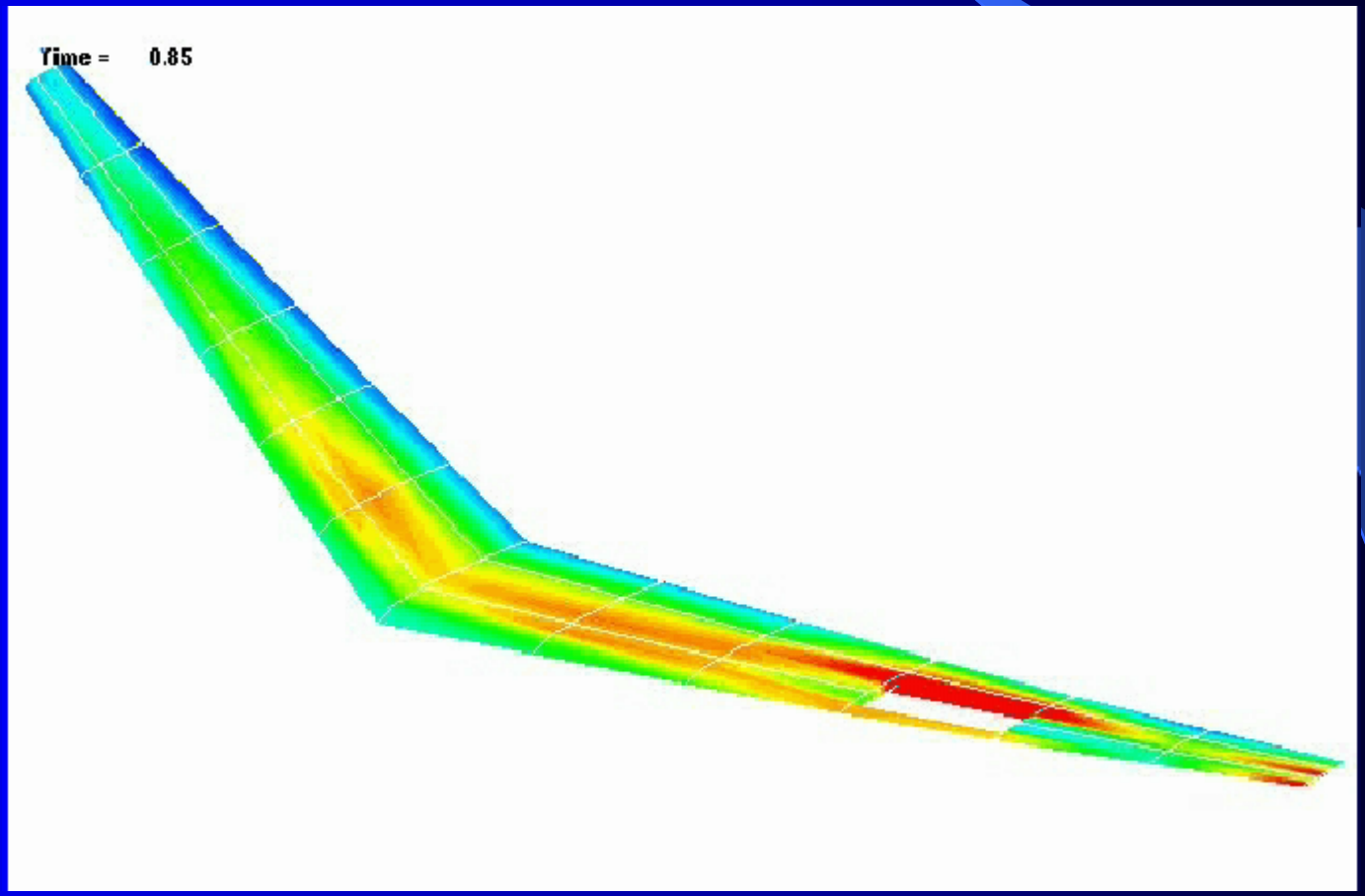
- Model Is Fixed At Root Chord
- Air Flow And Structure Modeled Tip To Tip



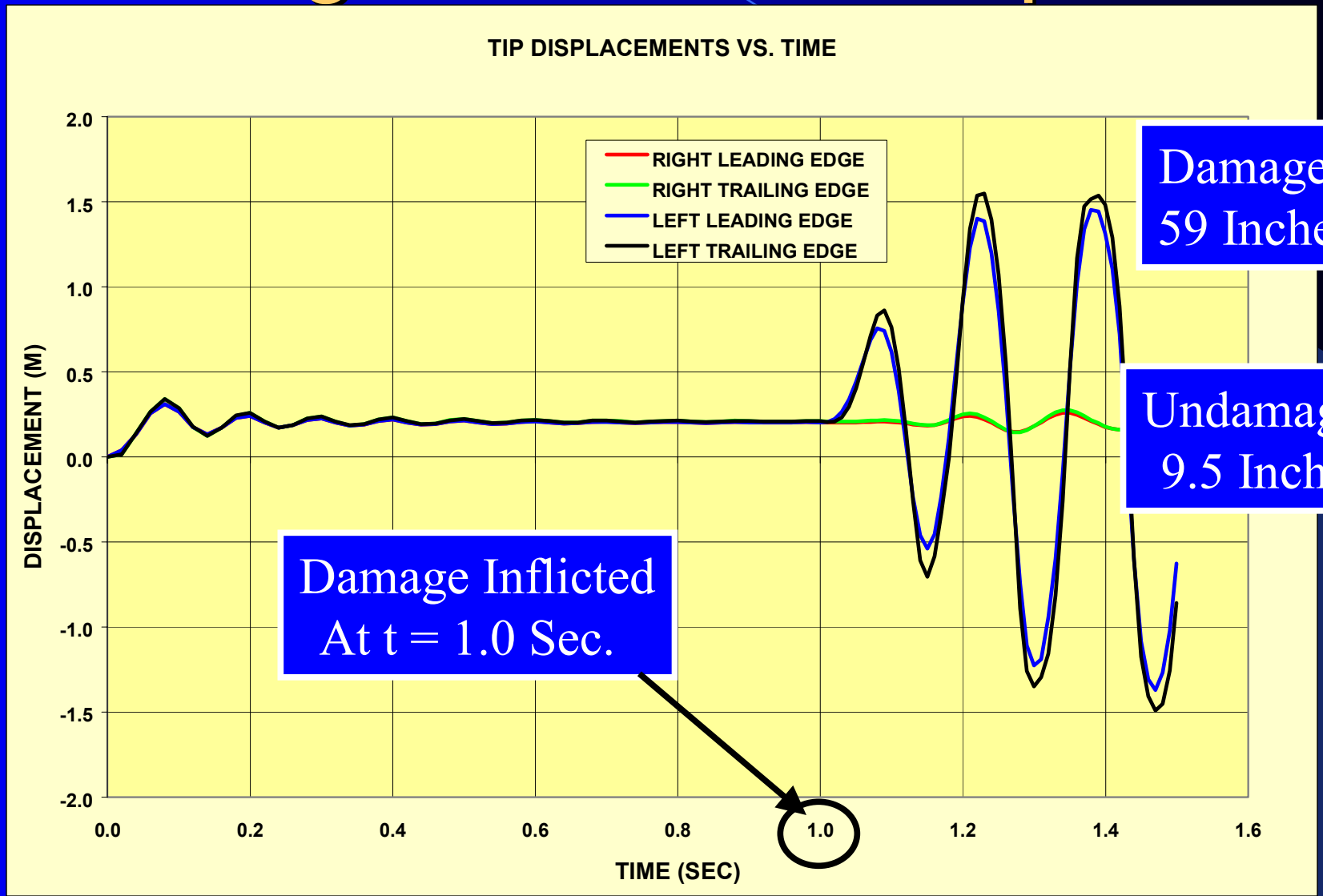
Damage Well Below Flutter Speed



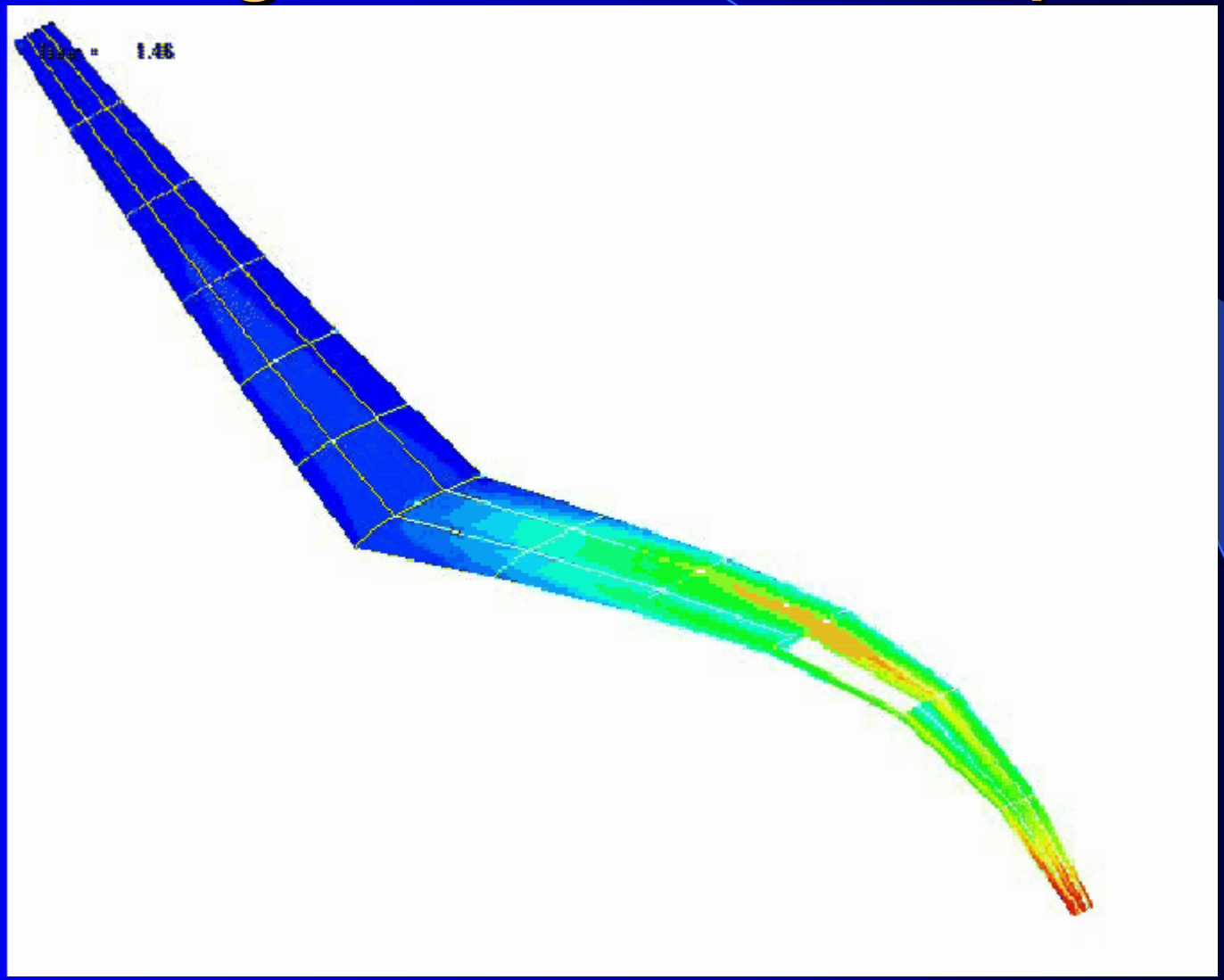
Damage Well Below Flutter Speed



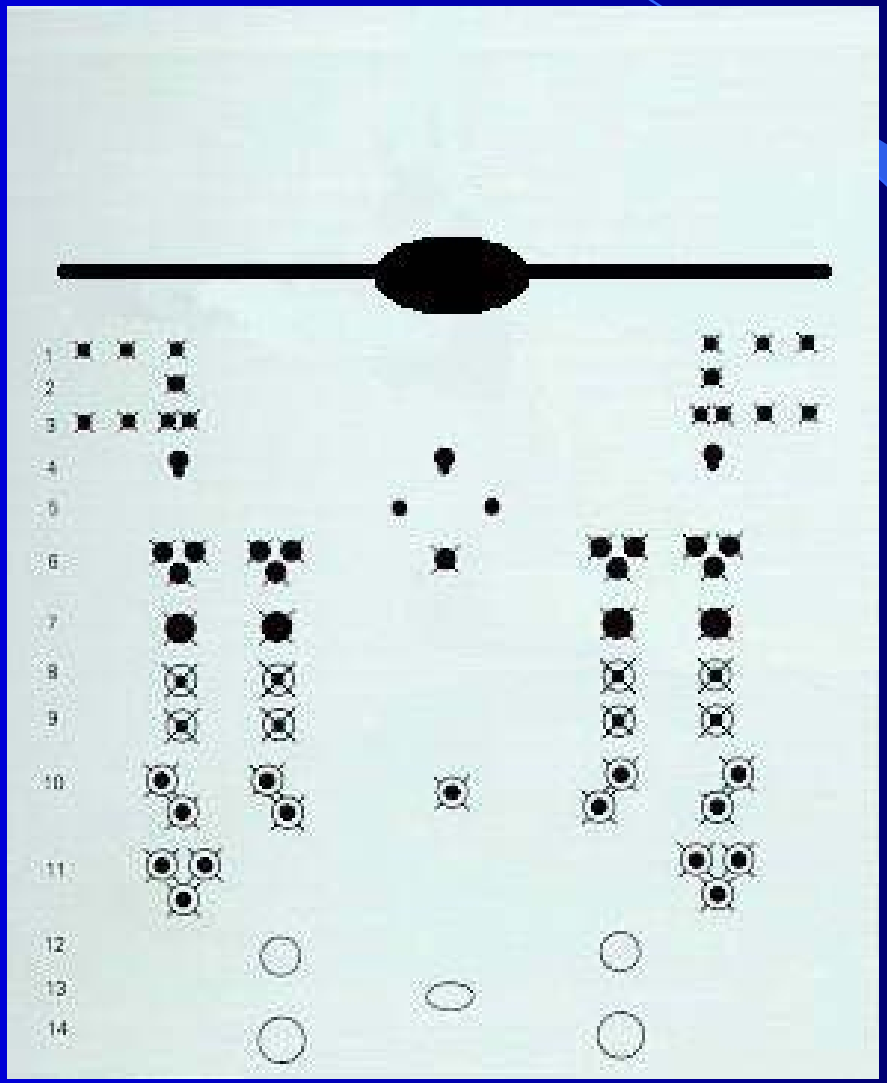
Damage Near Flutter Speed



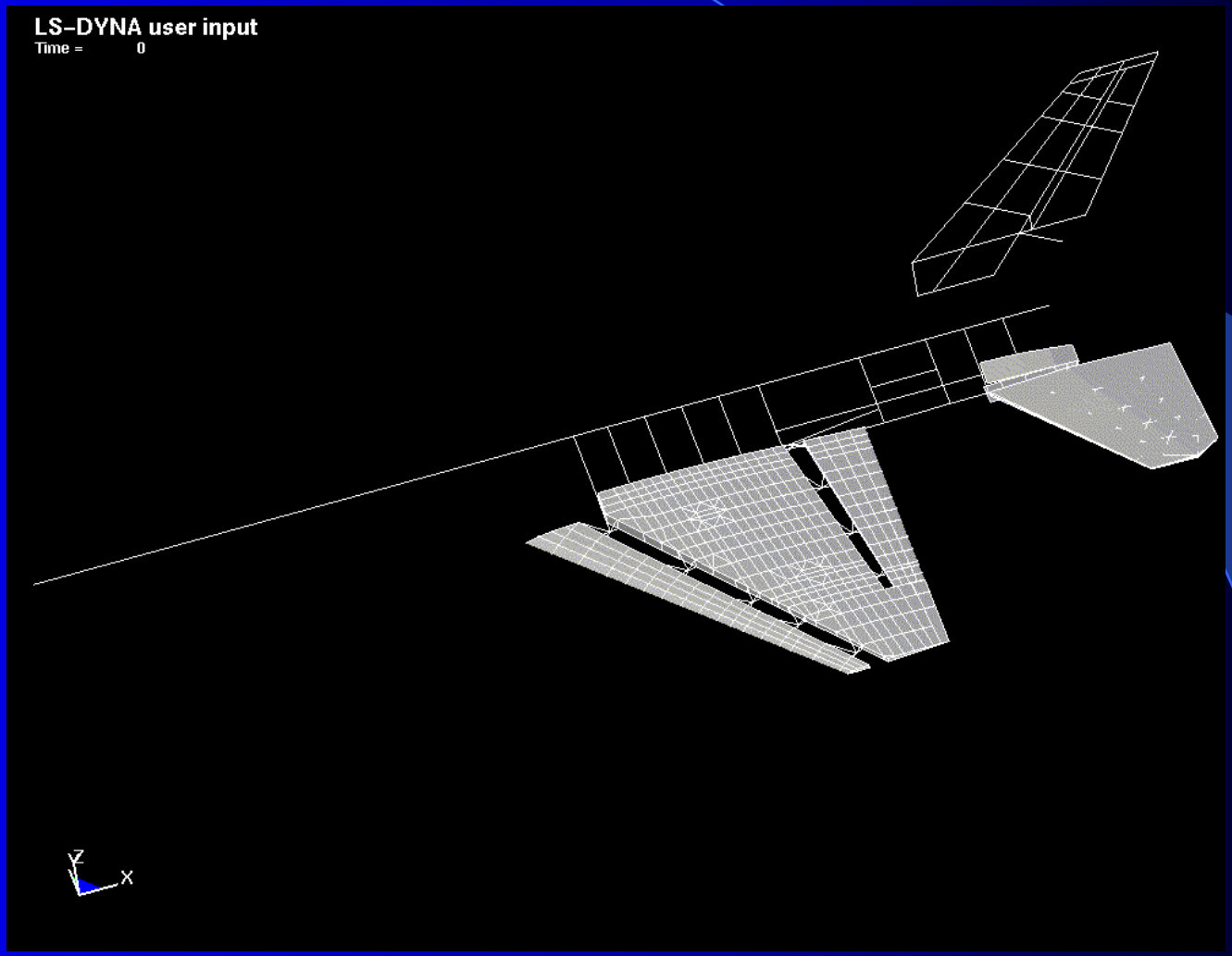
Damage Near Flutter Speed



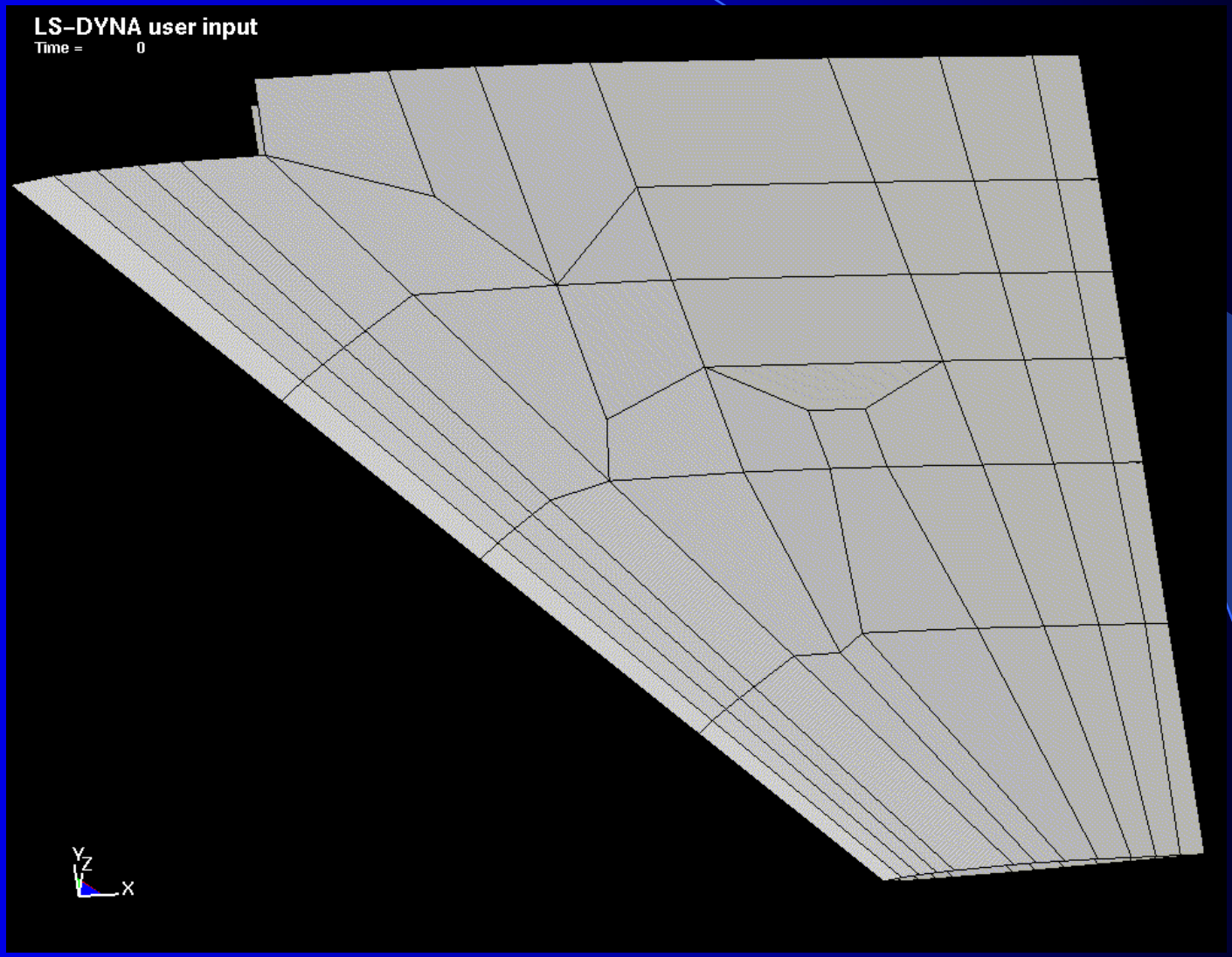
Frequently Used Configurations



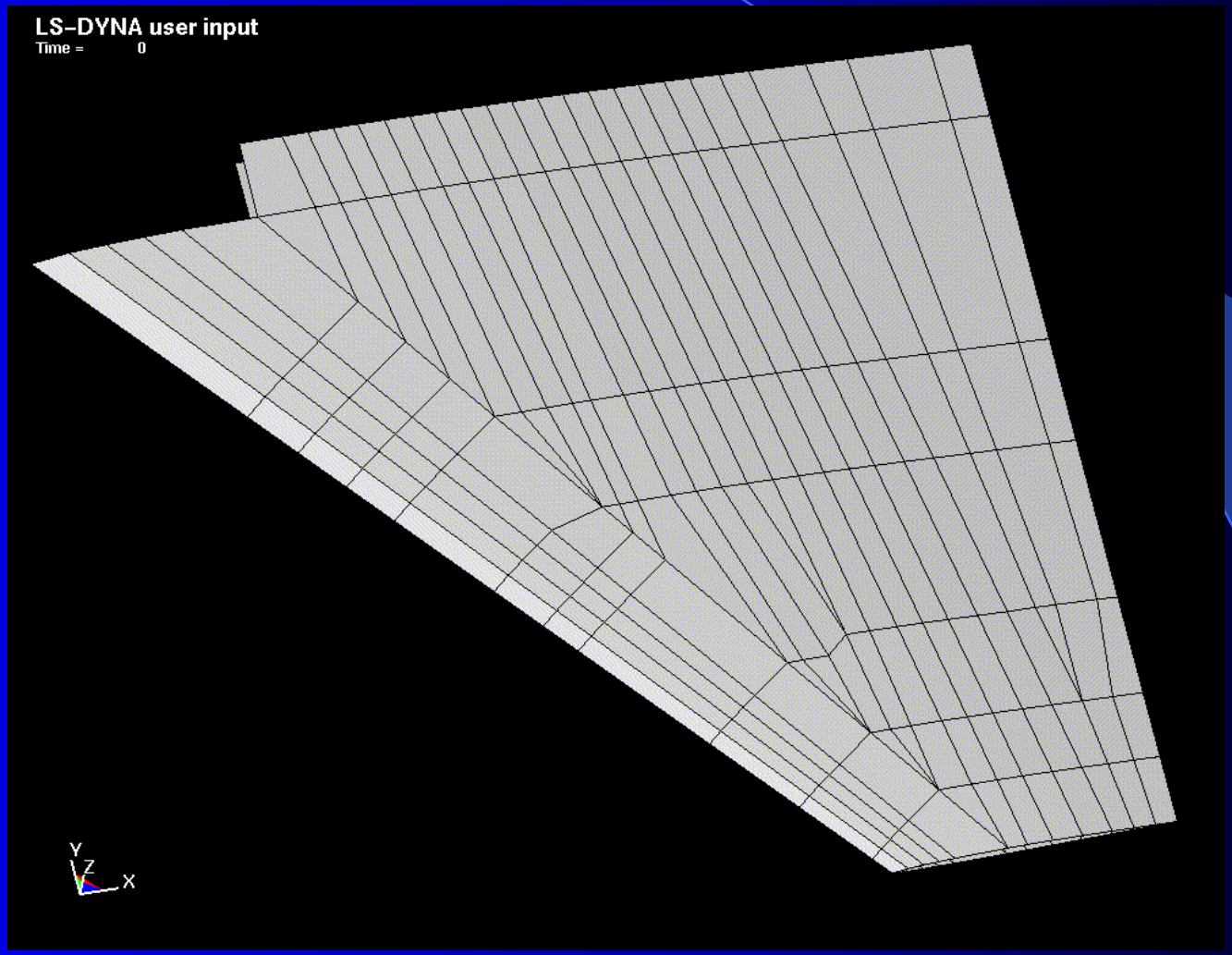
Structural Model



Aero Coarse Mesh

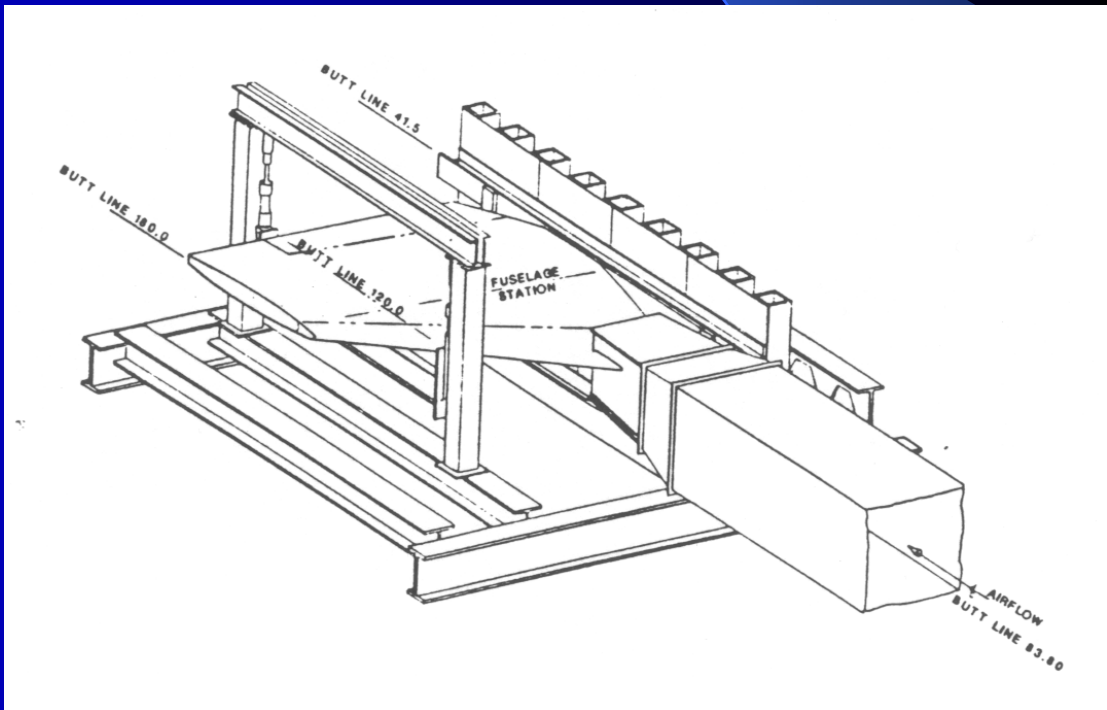


Aero Mesh Refinement

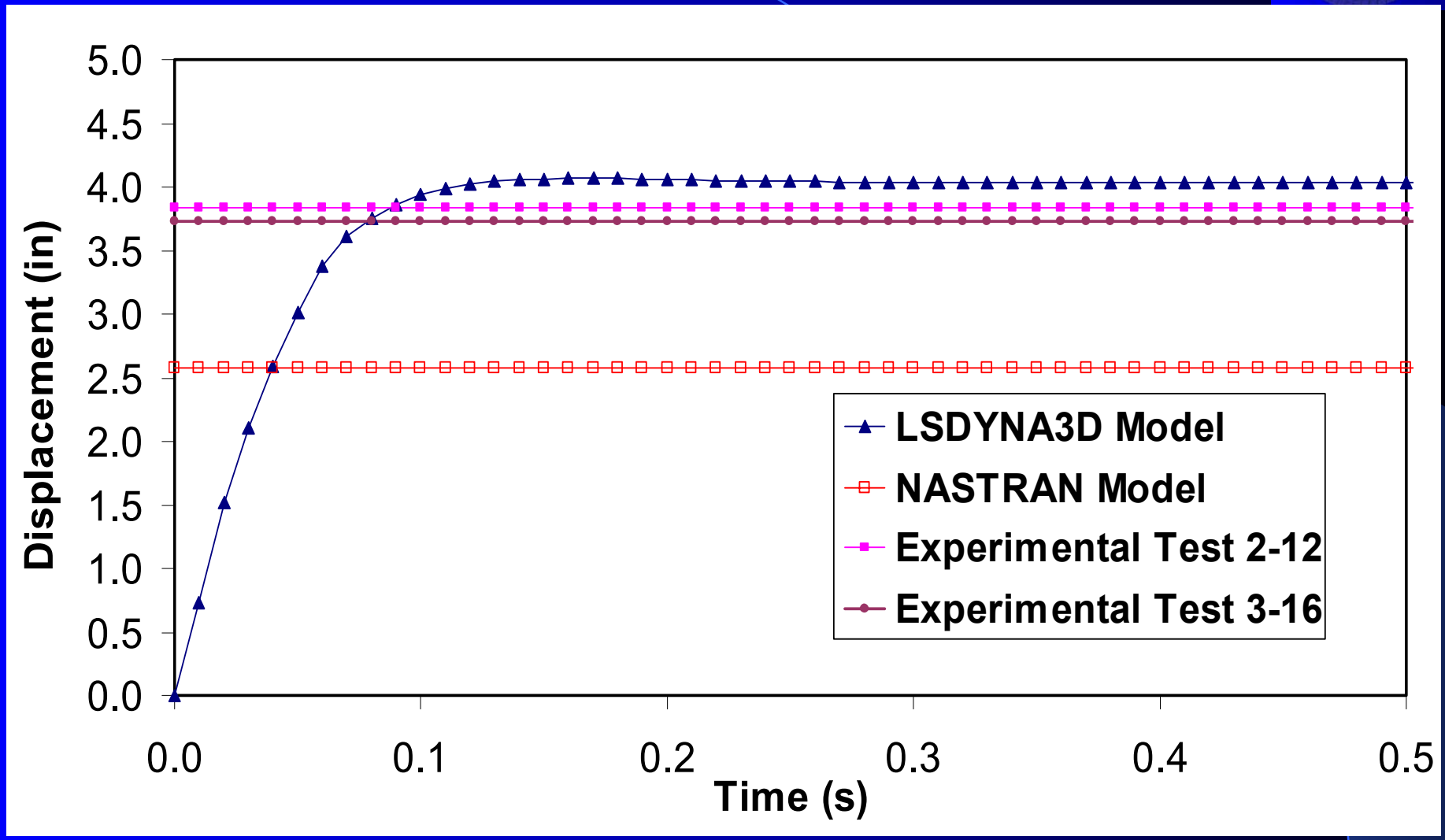


Model Validation Results

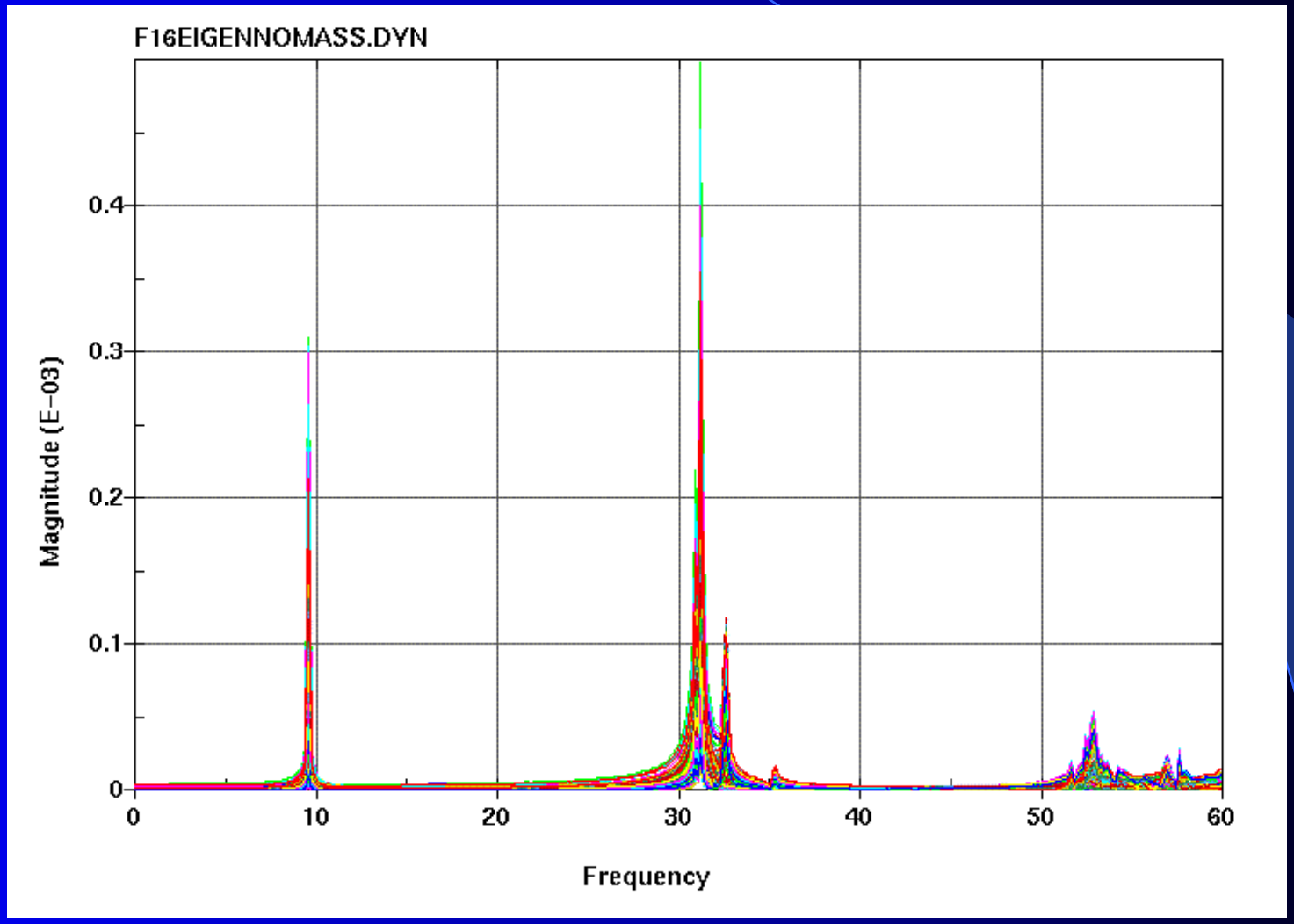
- **Displacement Comparisons**
  - **Static Line Load Simulation**
  - **Dynamic**
  - **Experimental Data**



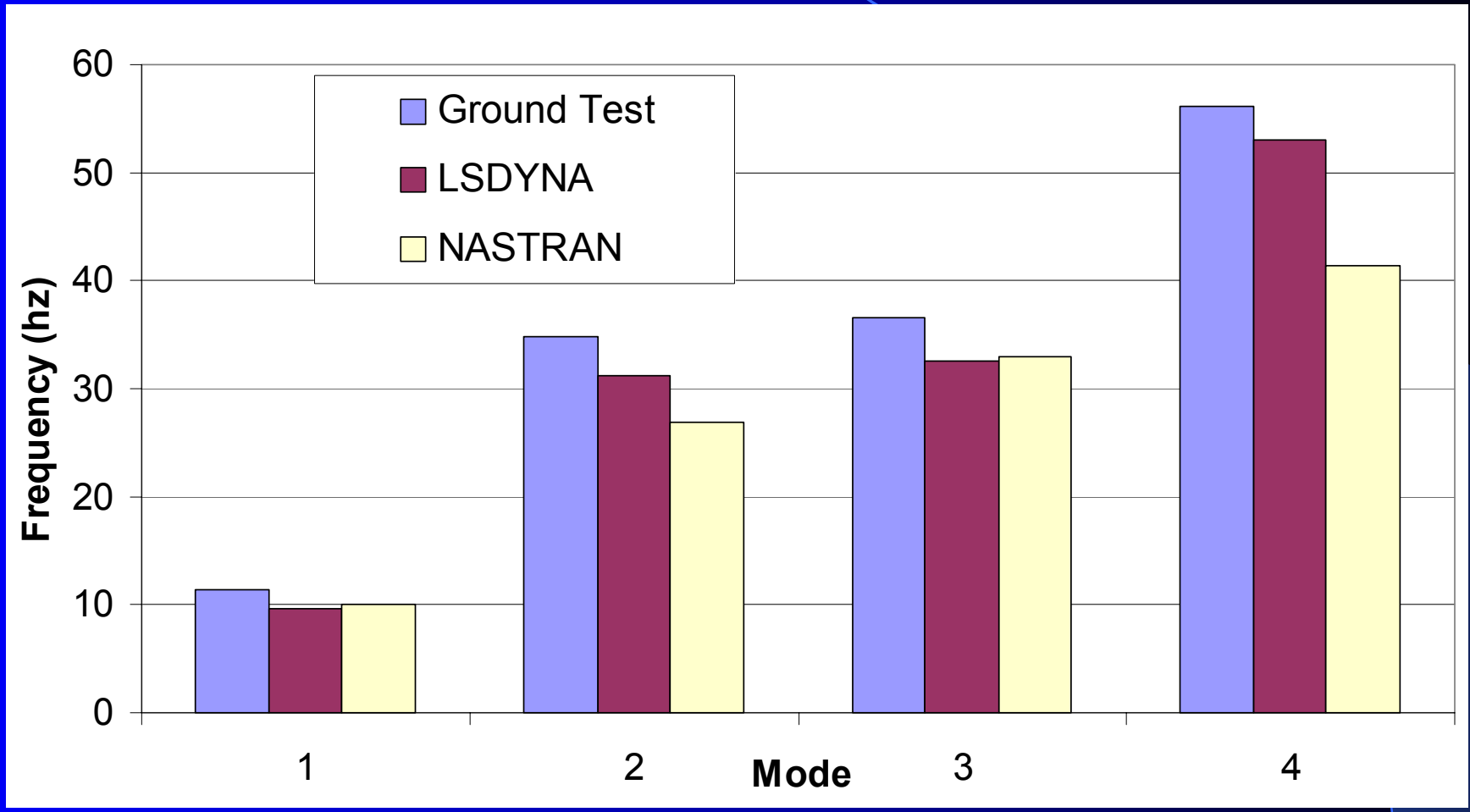
Static Line Load Simulation



Dynamic Validation



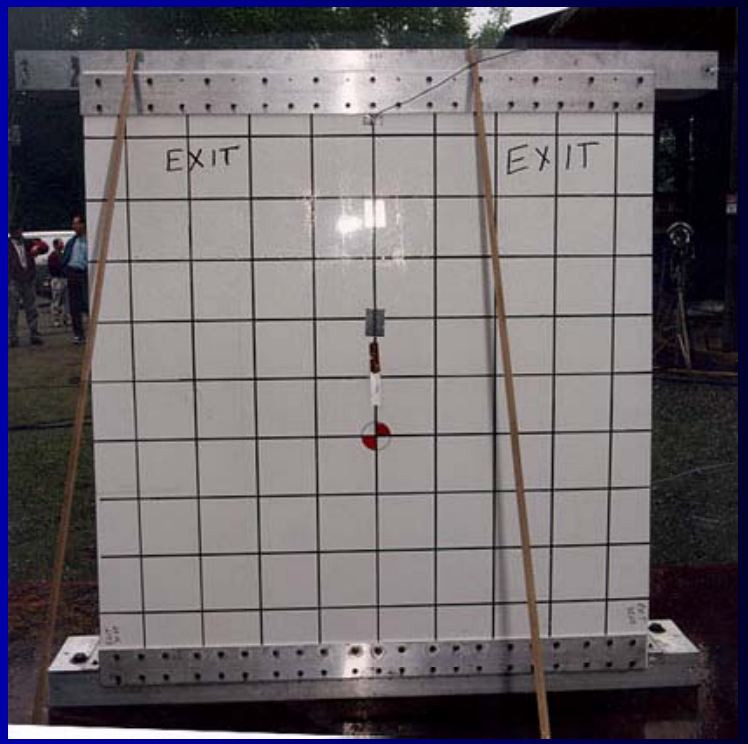
Dynamic (Eigenvalues Verified)

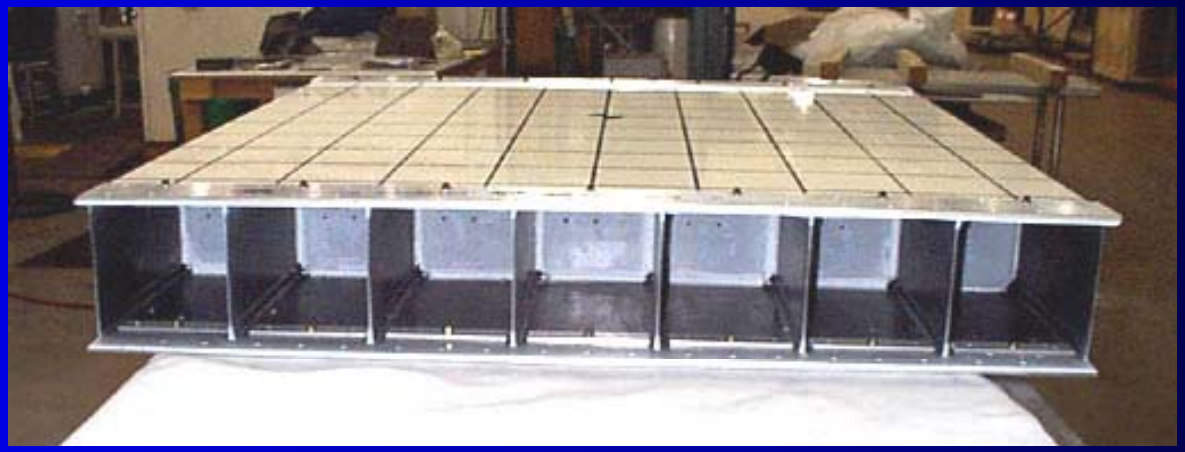


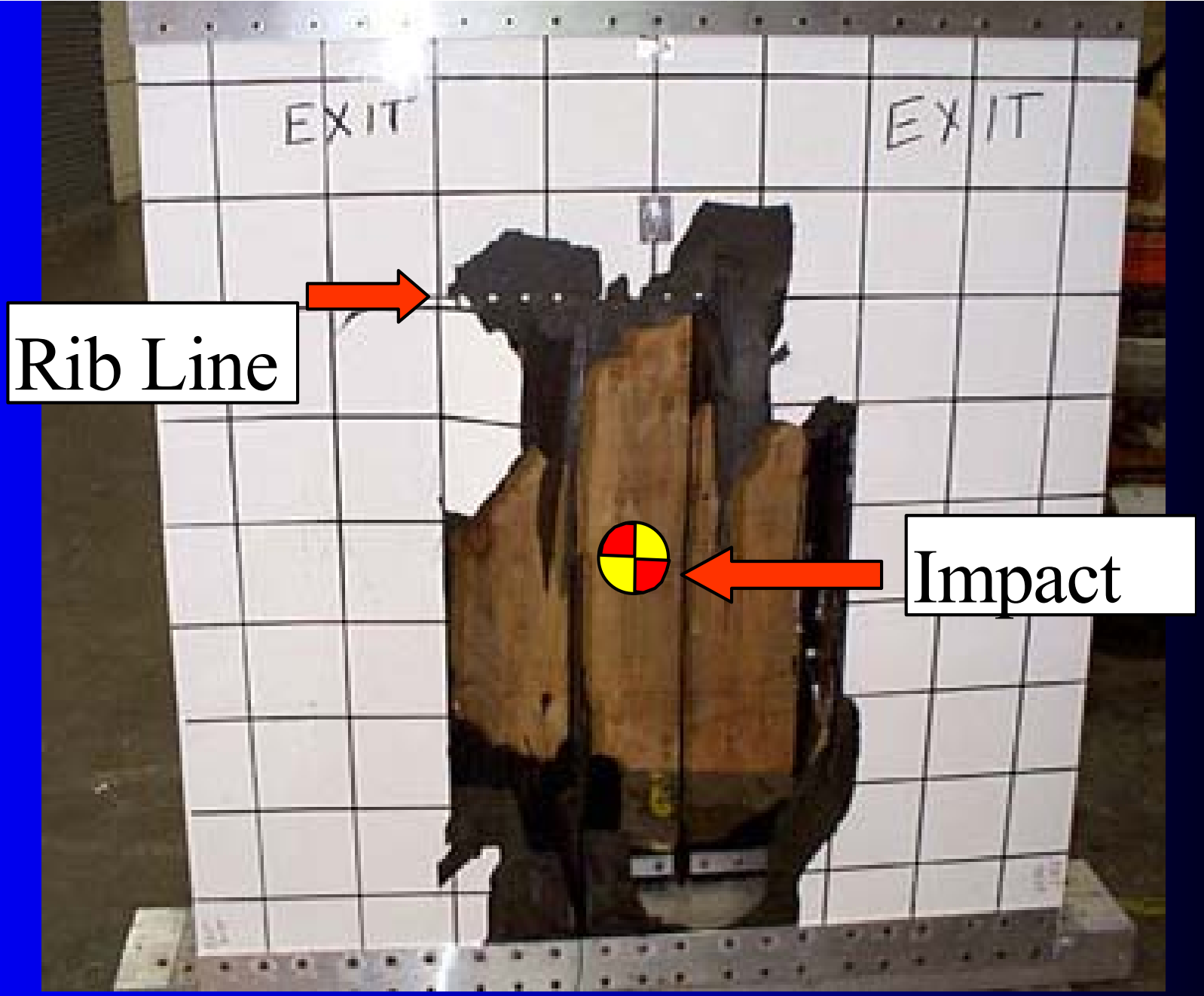
Sample Cases

- Typical HEI HRAM Damage
  - Loss of spars & skin
- Mach 0.80, 0.92– Near Wing Root Damage
  - Clean Wing
  - With Store-01
  - 3 & 6 Degree Angle of Attack
- Mach 0.95 Near Wing Tip Damage
  - Clean Wing

Test Component Fabricated

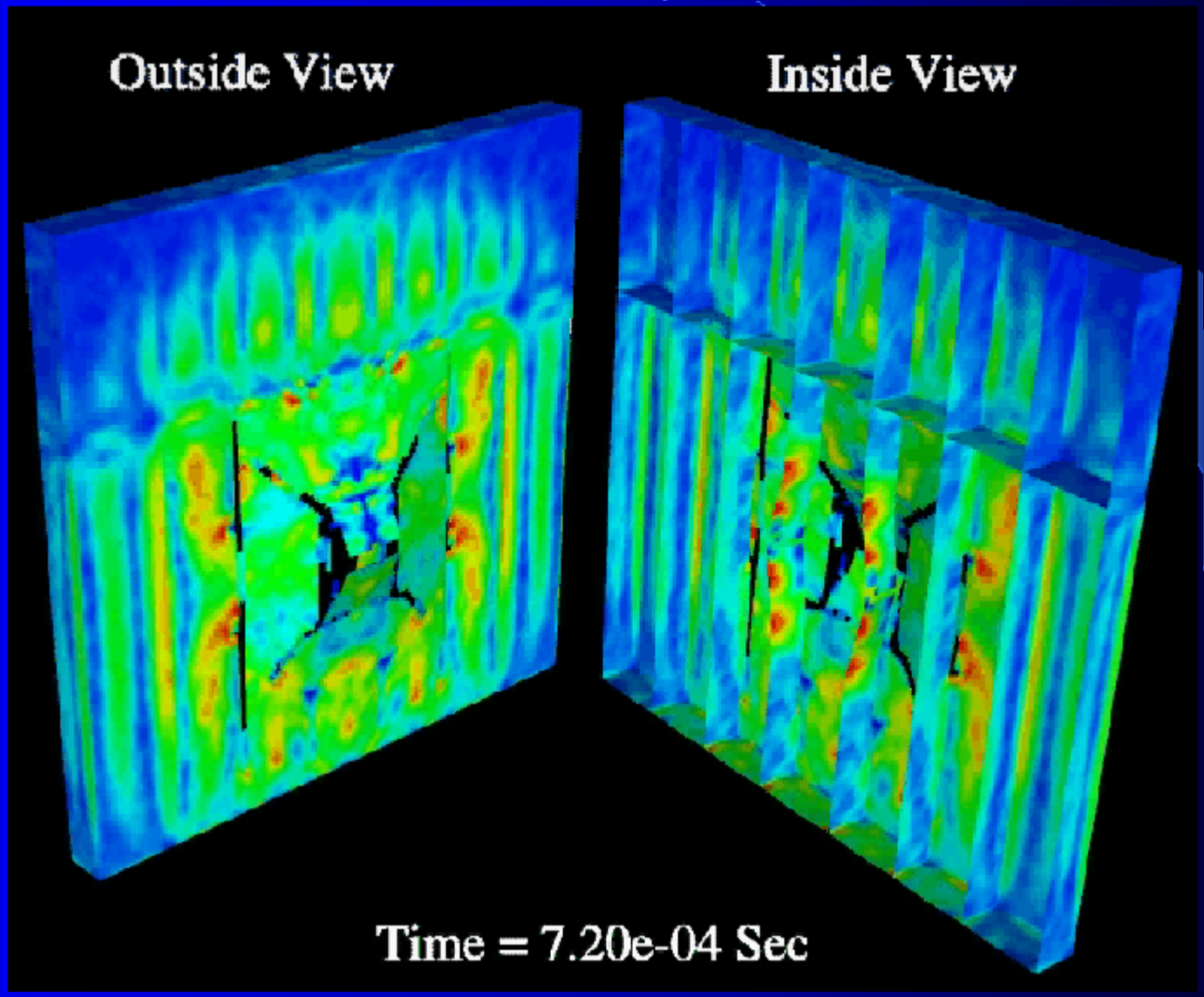






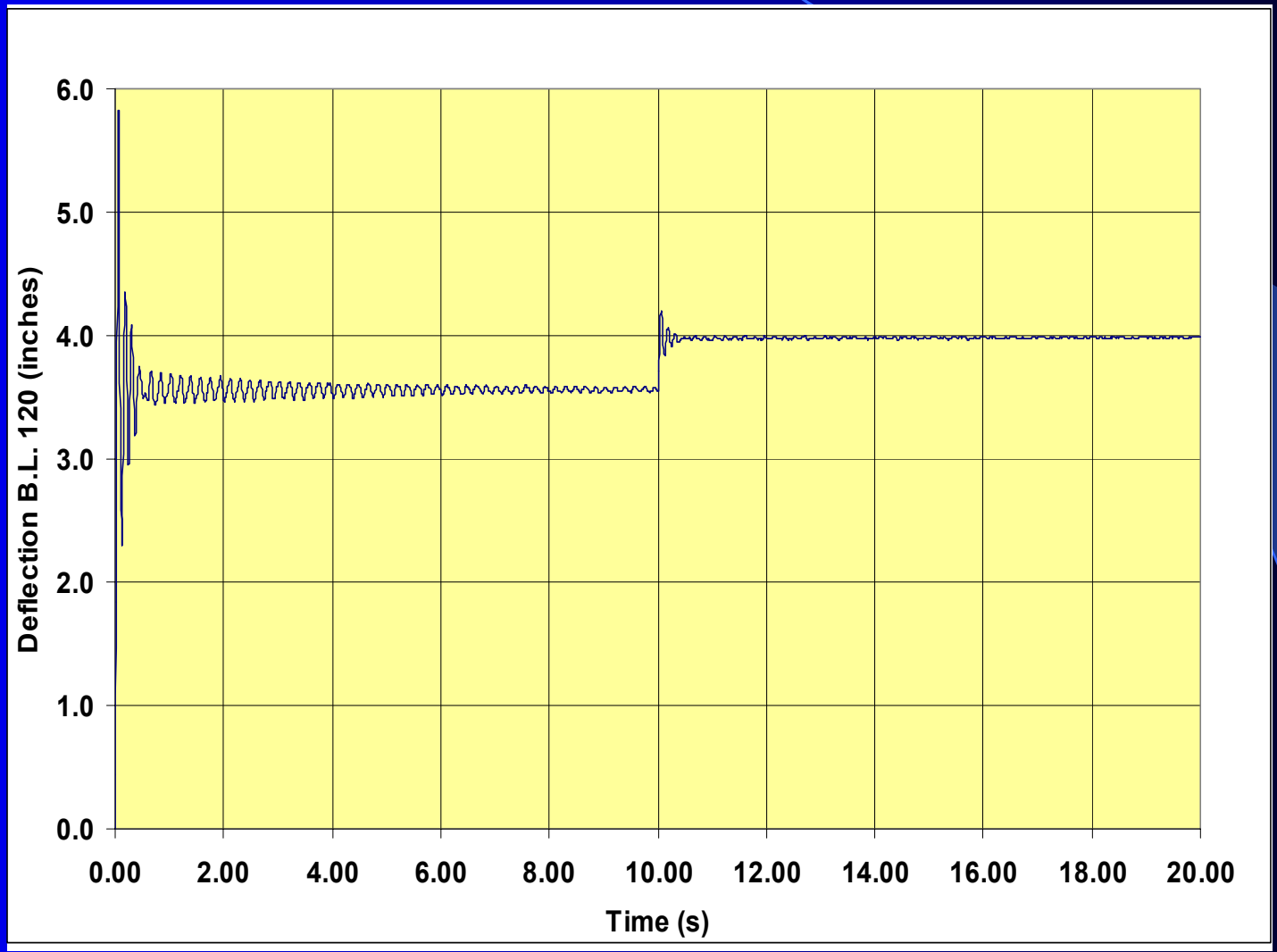
Photograph Of Damaged Box

HRAM Modeling



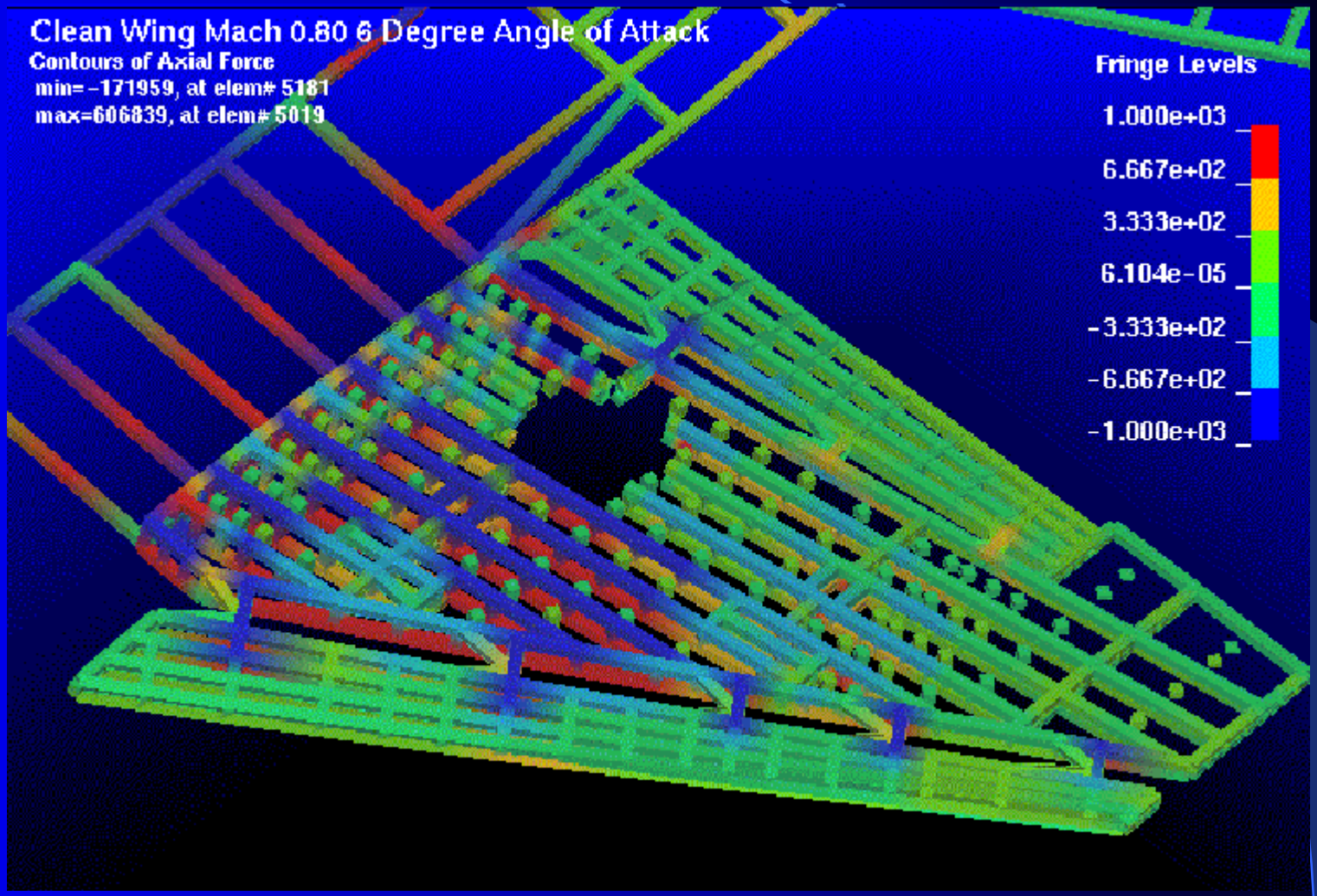
Sample Cases

Clean Wing - Mach 0.80
Angle of Attack 6 Degrees

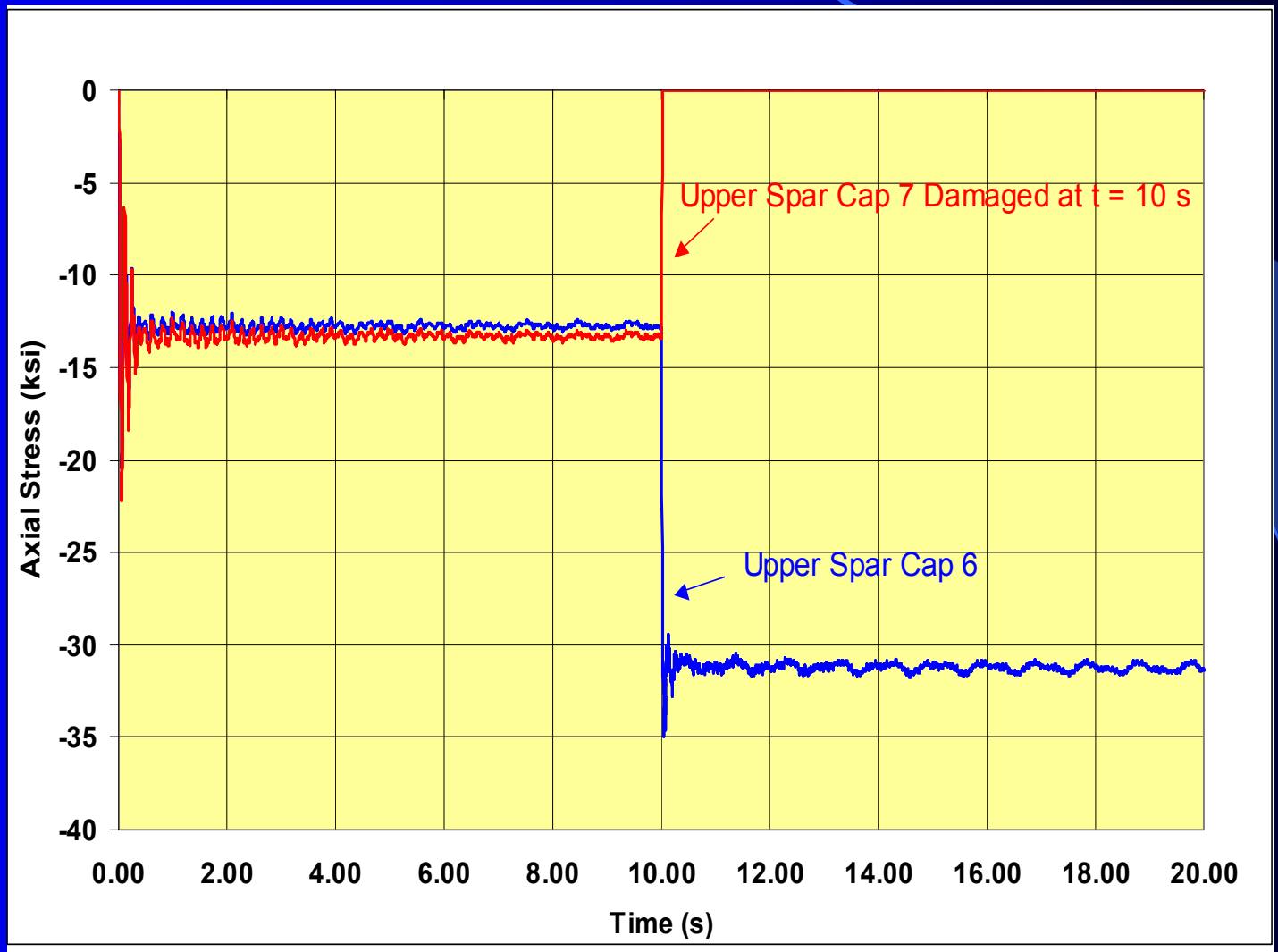


Sample Cases

Clean Wing - Mach 0.80
Angle of Attack 6 Degrees

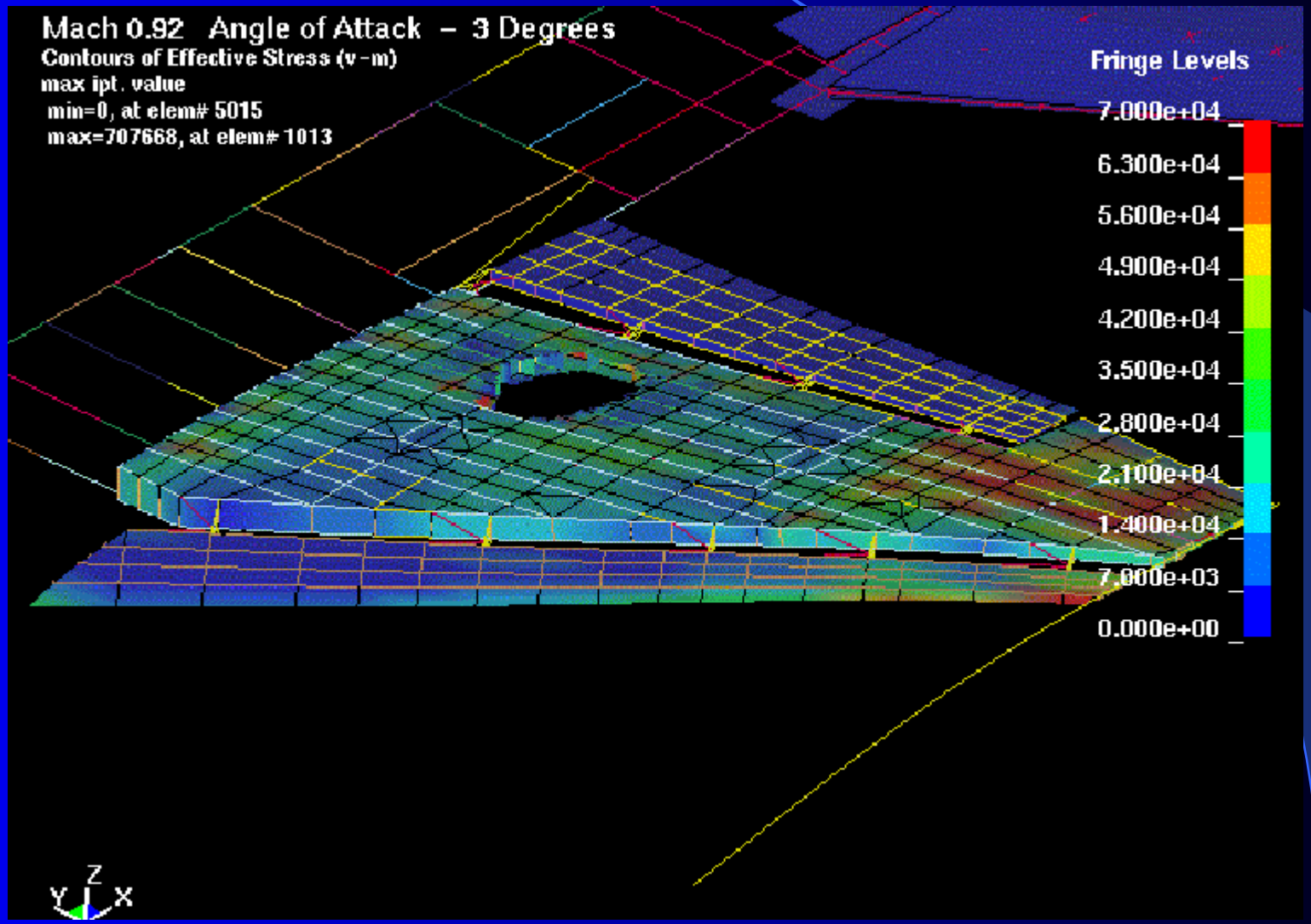


Sample Spar Cap Load Redistribution



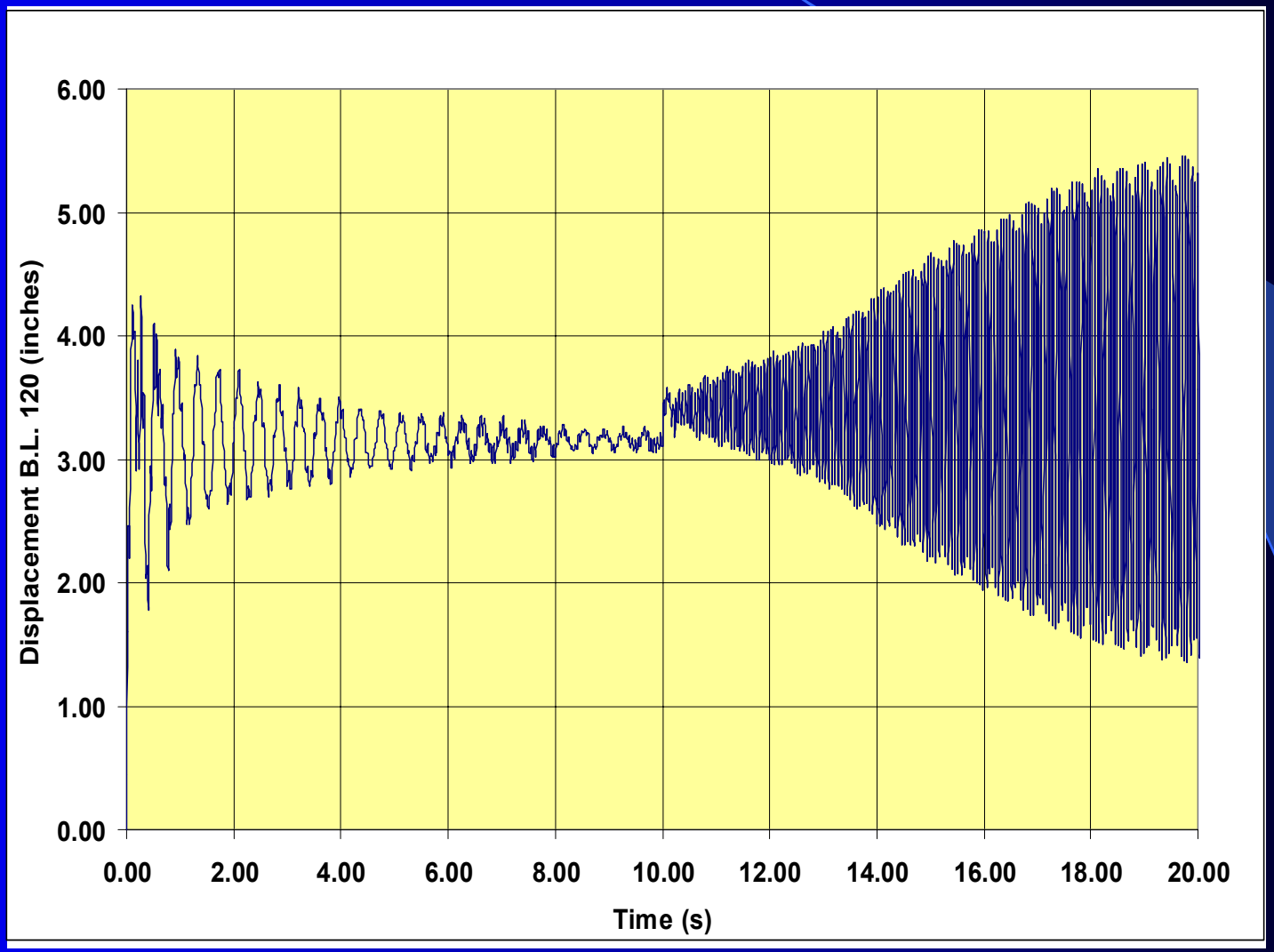
Sample Cases

Store-01 - Mach 0.92
Angle of Attack 3 Degrees



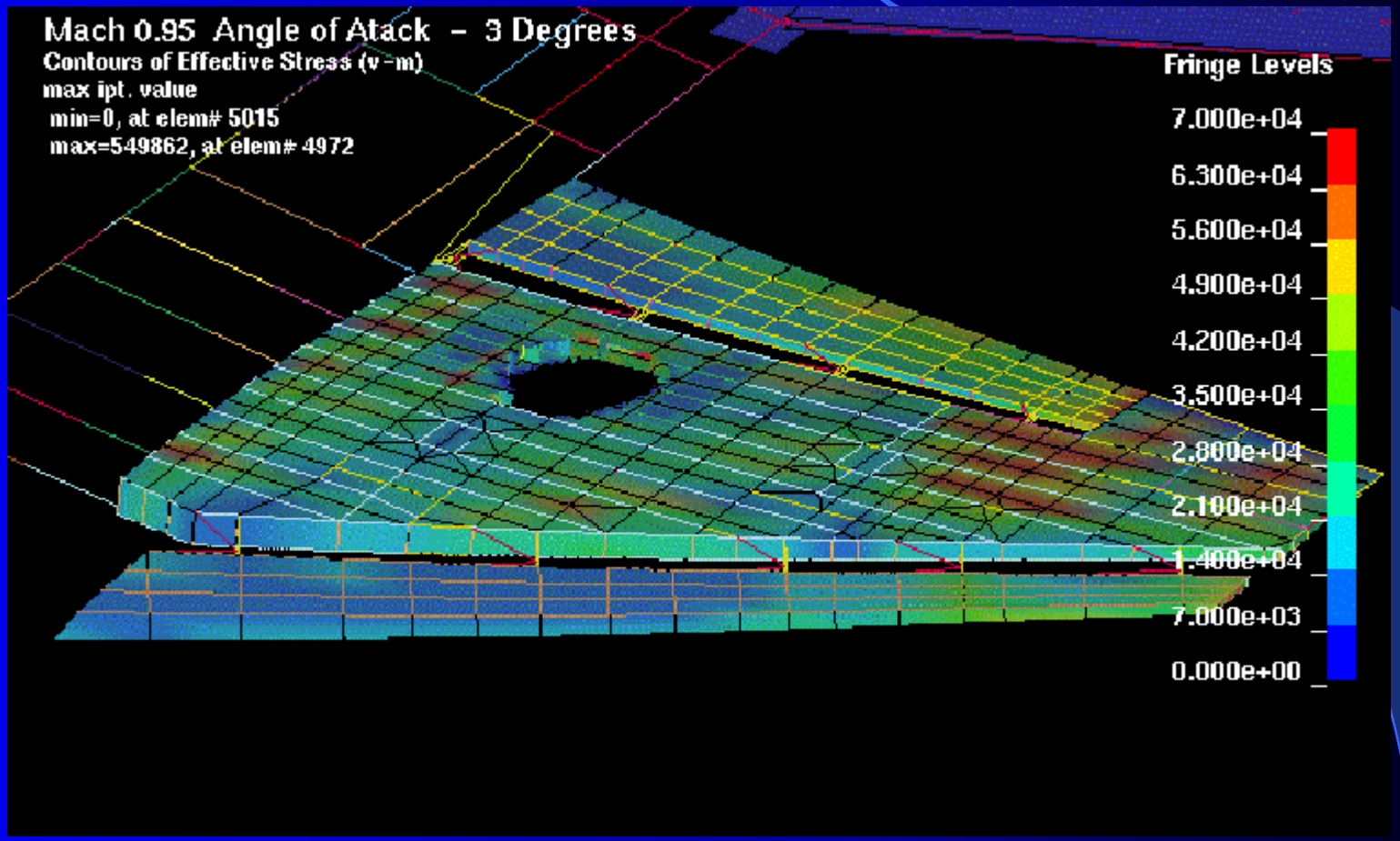
Sample Cases

Store-01 - Mach 0.92
Angle of Attack 3 Degrees



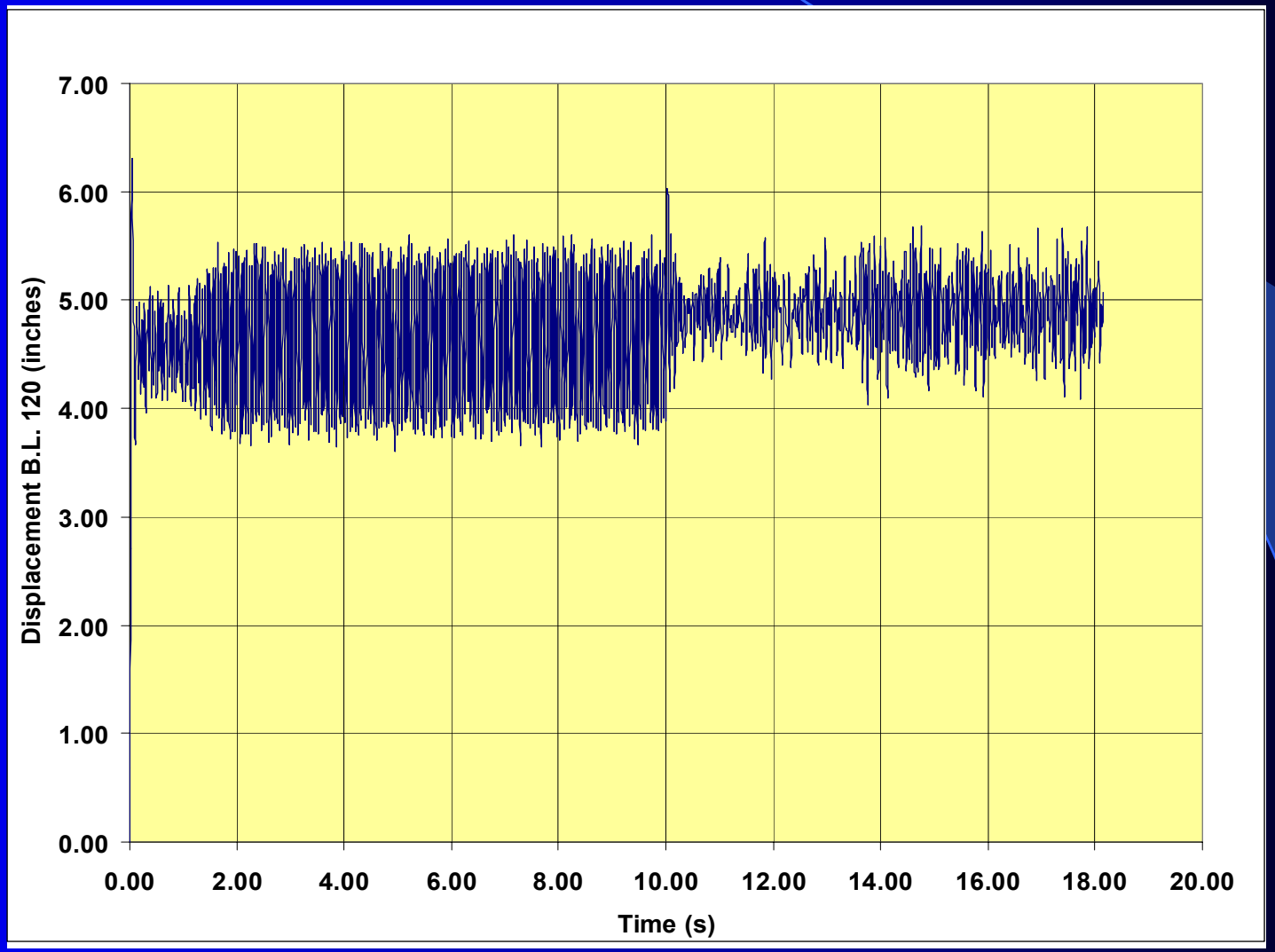
Sample Cases

Clean Wing - Mach 0.95
Angle of Attack 3 Degrees



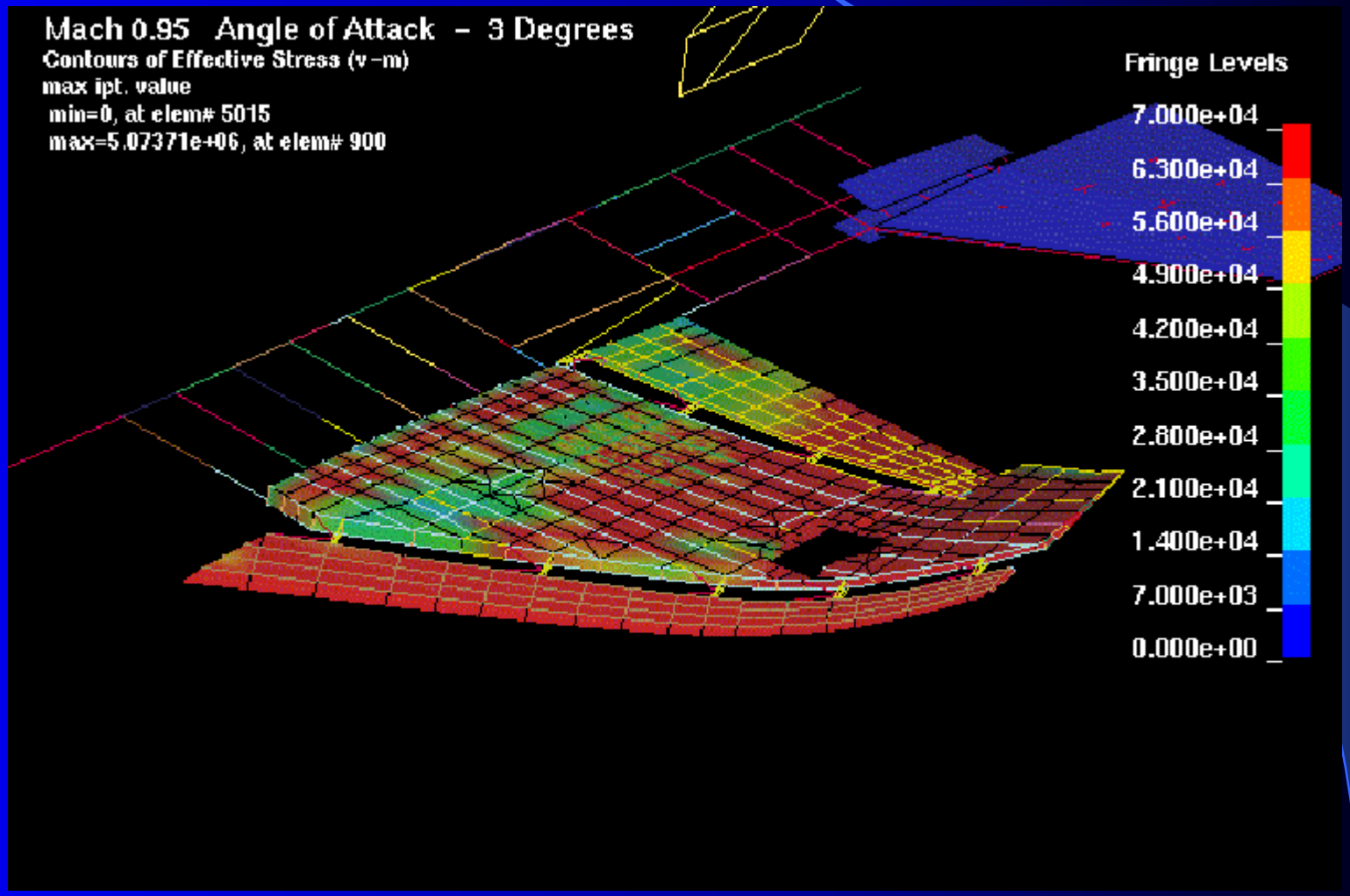
Sample Cases

Clean Wing - Mach 0.95
Angle of Attack 3 Degrees



Sample Cases

Clean Wing Tip Damage - Mach 0.95
Angle of Attack 3 Degrees



Possible Strategy

Stores
Store-01, Store-02, Store-03, etc.

Aircraft
Selection

Flight Conditions
Velocity, Angle of Attack,
Altitude, etc.

Shot Line Locations &
Fuel Load

Dynamic
Finite Element
Modeling

Static Testing Conditions

Dynamic Testing Condit

Superposition ?

Survives ???

Conclusions

- Dynamic Loading Methodology Should Consider
  - Stores, Aircraft, Flight Conditions, & Shot Lines
- Testing
  - Static / Dynamic
- Possible Solution
  - Hydraulic / Pneumatic
- Dynamic ground testing to be applied when flutter is not predicted
- Computational analysis used as the primary tool for post damage survivability when flutter is predicted